CDI MARINE COMPANY

Bldg. 2, 9951 Atlantic Boulevard, Jacksonville, Florida 32211 (904) 724-9700

January 16, 1985

Dear Texas Instruments
Custom Croms:

I have currently written a series of 10 TI-59 programs on 20 cards (2 cards per program). Each program has approx. 800 steps, and using the cards is very time consuming.

These programs are to be worked with the worksheets (attached). I can work problems in minutes that take hours by hand and be completely documented.

The worksheet/program combination has unlimited potential, whereas the small computers are limited in time and printing capacity. For Civil Engineers these 10 programs can be of great use. There will always be a need for hand calculations in Civil Engineering.

Please let me know how much it costs for approx. 12,000 steps to be put on a crom. Is there a way I can add to the capacity of my TI-59? Is there a price reduction for ordering 10 of the same croms? From a marketing standpoint the worksheet/program combination concept might be a way to help sell calculators. Let me know about the future of the TI-59's.

Thank you,

Paul C. Honour

Paul C. Honour
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TITLE BEAMS (1.) TO (10.) PAGE 1. OF 12.

TI Programmable Program Record

PROGRAMMER P.C. HONOUR DATE 1/16/85

Partitioning (Op 17) 7, 1, 9, 2, 9 Library Module N/A Printer REQ'D Cards 2-Both Sides

PROGRAM DESCRIPTION

Computes: Reactions, Bending Moments, Shear & Bending Stress and deflection due to bending at any pre-selected point in a single span beam of constant cross section. There are 10 different BM. conditions & one program for each. All programs are input & used the same way. The principals of superposition are used, thus allowing rapid results with various combinations. Programs take from 20 - 40 seconds each to run and should be used w/attached worksheets.

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
	1) Before input of magnetic cards, set up partition memory by entering: 3 2nd OP 17, calculator display should respond with 719.29. (719 program steps & 29 memory locations.)			
	2) The following steps are for input of magnetic cards:			
	a) Enter bank #1 (1), INV, 2nd & R/S.			
	b) Place magnetic card in lower right slot and calculator will pull it thru.			
	c) If display is flashing when card exists, reread card (steps a & b) if bank # is displayed, then card was read.			
	d) Enter bank numbers 2, 3 & 4 and read magnetic cards in the same manner.			
	3) RST, R/S starts program W/A verified set of numbers from a worksheet using memory locations 1 2 3 4 5 6 20 21. (Memory Locations)			
	4) For a new analysis Input quanities in memory locations as described in step 3. and RST, R/S will re-start program.			

USER DEFINED KEYS	DATA REGISTERS (INV List)		LABELS (Op 08)
A	0	0	INV lnx CE CLR x:t x²
B	1	1	√x 1/x STO RCL SUM yˣ
C	2	2	EE ( ) ÷ GTO ×
D	3	3	SBR − RST + R/S •
E	4	4	+/− = CLR INV log CP
A'	5	5	tan Pgm P→R sin cos CMs
B'	6	6	Exc Prd |x| Eng Fix Int
C'	7	7	Deg Pause x=t Nop Op Rad
D'	8	8	Lbl x≥t Σ+ x̄ Grad St flg
E'	9	9	If flg D.MS π List Write Dsz
			Adv Prt

PRELIMINARY

FLAGS	0	1	2	3	4	5	6	7	8	9

CDI MARINE COMPANY
NAVAL ARCHITECTS AND MARINE ENGINEERS
JACKSONVILLE, FLORIDA

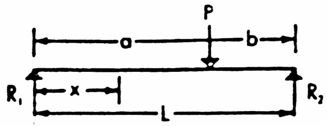
BY P.C. Honour DATE 1/16/85 SUBJECT BEAMS (1.) TO (10.) SHEET NO. 2 OF 12

CHKD BY ________ DATE ________ ________ JOB NO. —

VISUAL INDEX TO FORMULAS ON FOLLOWING PAGES
FOR VARIOUS BEAM-LOAD CONDITIONS

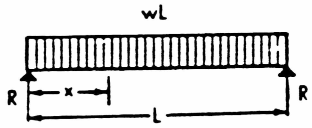
Beam supported at both ends
Concentrated load at any point

1.



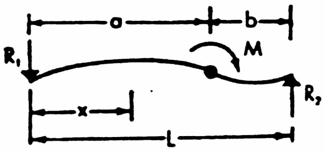
Beam supported at both ends
Uniform load over entire span

2.



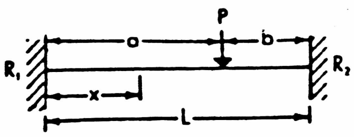
Beam supported at both ends
Moment applied at any point

3.



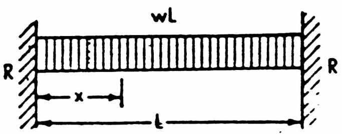
Beam fixed at both ends
Concentrated load at any point

4.



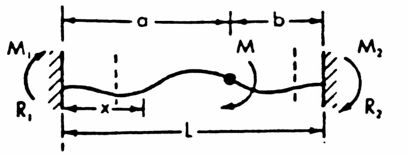
Beam fixed at both ends
Uniform load over entire span.

5.



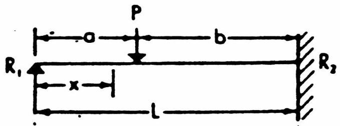
Beam fixed at both ends
Moment applied at any point

6.



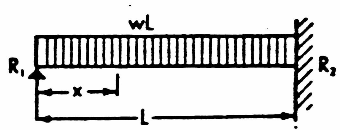
Beam fixed at one end and supported at the other end
Concentrated load at any point

7.



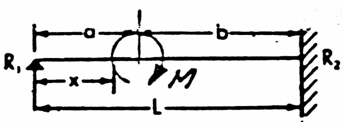
Beam fixed at one end and supported at the other end
Uniform load over entire span

8.



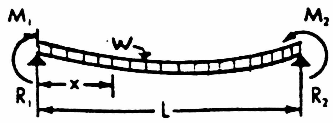
Beam fixed at one end and supported at the other end
Moment applied at any point

9.



Beam supported at both ends
Moments applied at each end
Uniform load over entire span

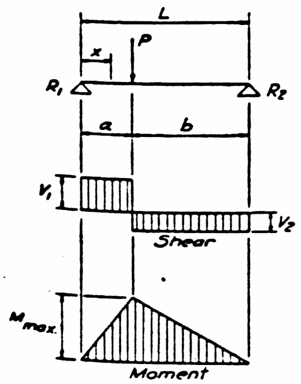
10.



CDI MARINE COMPANY
NAVAL ARCHITECTS AND MARINE ENGINEERS
JACKSONVILLE, FLORIDA

BY Paul C. Horn DATE 1/16/85 SUBJECT Beam I SHEET NO. 3 OF 12

CHKD BY ______ DATE ______ SIMPLE BEAM—CONCENTRATED LOAD AT ANY POINT JOB NO. —



	o.k.	n.g.
BENDING	☐	☐
SHEAR	☐	☐
DEFLECTION	☐	☐

Equivalent Tabular Load.............. $= \frac{8Pab}{L^2}$

$R_1 = V_1$ (max when $a < b$)............ $= \frac{Pb}{L}$

$R_2 = V_2$ (max when $a > b$)............ $= \frac{Pa}{L}$

M_{max} (at point of load)............... $= \frac{Pab}{L}$

M_x (when $x < a$)..................... $= \frac{Pbx}{L}$

$\Delta_{max}\left[\text{at } x = \sqrt{\frac{a(a+2b)}{3}} \text{ when } a > b\right]. = \frac{Pab(a+2b)\sqrt{3a(a+2b)}}{27EIL}$

Δ_a (at point of load)............... $= \frac{Pa^2b^2}{3EIL}$

Δ_x (when $x < a$)..................... $= \frac{Pbx}{6EIL}(L^2 - b^2 - x^2)$

P Concentrated load (kips).

a Measured distance along beam (in.).

b Measured distance along beam which may be greater or less than "a" (in.).

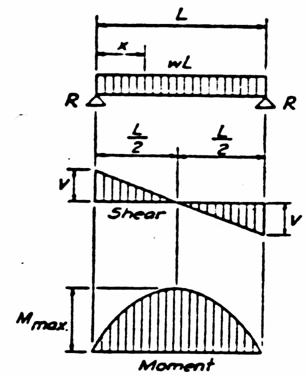
l Total length of beam between reaction points (in.).

x Any distance measured along beam from left reaction (in.).

E Modulus of Elasticity of steel at 29,000 ksi.

1	2	3	4	5	6	20	21
P (kips)	a (in.)	b (in.)	L (in.)	x (in.)	I (in.⁴)	S (in.³)	A-eff. (in.)
1.2	13	47	60	6.11	13.2	10.9	1.5

```
BEAM (1.)
EQ. TAB. LOAD
        1.6293
R1
        0.9400
R2
        0.2600
M-MAX
       12.2200
MX
        5.7434
D-MAX
        0.0082
DA
        0.0065
DX
        0.0034
M-MAX/S
        1.1211
R1/A-EFF
        0.6267
R2/A-EFF
        0.1733
```



	o.k.	n.g.
BENDING	☐	☐
SHEAR	☐	☐
DEFLECTION	☐	☐

```
BEAM (2.)
EQ. TAB. LOAD
       28.0000
R=V
       14.0000
VX
       -9.2000
M-MAX
      490.0000
MX
      278.4000
D-MAX
        0.6412
DX
        0.3328
M-MAX/S
       44.9541
R=V/A-EFF
        9.3333
```

Equivalent Tabular Load........ $= wL$

$R = V$........................ $= \frac{wL}{2}$

V_x.......................... $= w\left(\frac{L}{2} - x\right)$

M_{max} (at center)................ $= \frac{wl^2}{8}$

M_x.......................... $= \frac{wx}{2}(L - x)$

Δ_{max} (at center)................ $= \frac{5wl^4}{384EI}$

Δ_x.......................... $= \frac{wx}{24EI}(l^3 - 2Lx^2 + x^3)$

w Uniformly distributed load per unit of length (kips per in.).

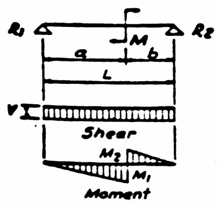
l Total length of beam between reaction points (in.).

x Any distance measured along beam from left reaction (in.).

E Modulus of Elasticity of steel at 29,000 ksi.

1	2	3	4	5	6	20	21
w (kip/in.)	a (in.)	b (in.)	L (in.)	x (in.)	I (in.⁴)	S (in.³)	A-eff. (in.)
.20			140	116	53.8	10.9	1.5

	o.k.	n.g.
BENDING	☐	☐
SHEAR	☐	☐
DEFLECTION	☐	☐



$R_1 = V$ .... $= -\frac{M}{L}$

R_2 .... $= \frac{M}{L}$

M_1 .... $= -\frac{Ma}{L}$

M_2 .... $= \frac{Mb}{L}$

M_{max} .... $= M_1$ if $a > b$

$= M_2$ if $a < b$

M_x (when $x < a$)...... $= -\frac{Mx}{L}$

M_x (when $x > a$)...... $= \frac{M}{L}(L - x)$

Δ_x (when $x < a$)...... $= \frac{Mx}{6EIL^2}(-a^3 - 3a^2b + 2b^3 + Lx^2)$

Δ_x (when $x > a$)...... $= \frac{M(L-x)}{6EIL^2}[-2a^3 + 3ab^2 + b^3 - L(L-x)^2]$

$$\Delta_{max}\left(\text{if } a > b, \text{ at } x = \sqrt{-\frac{2}{3}L^2 + 2aL - a^2}\right) =$$

$$\frac{M\sqrt{-\frac{2}{3}L^2 + 2aL - a^2}}{6EIL^2}\left(-a^3 - 3a^2b + 2b^3 - \frac{2}{3}L^3 + 2aL^2 - a^2L\right)$$

$$\Delta_{max}\left(\text{if } a < b, \text{ at } (L - x) = \sqrt{-\frac{2}{3}L^2 + 2bL - b^2}\right) =$$

$$\frac{M\sqrt{-\frac{2L^2}{3} + 2bL - b^2}}{6EIL^2}\left(-2a^3 + 3ab^2 + b^3 + \frac{2}{3}L^3 - 2bL^2 + b^2L\right)$$

M moment (kip in.)

a Measured distance along beam (in.).

b Measured distance along beam which may be greater or less than "a" (in.).

l Total length of beam between reaction points (in.).

x Any distance measured along beam from left reaction (in.).

E Modulus of Elasticity of steel at 29,000 ksi.

① M (kip in.)	② a (in.)	③ b (in.)	④ L (in.)	⑤ x (in.)	⑥ I (in.^{4})	⑳ S (in.^{3})	㉑ A-eff. (in.)
74	25	50	75	15	41.4	10.9	1.5

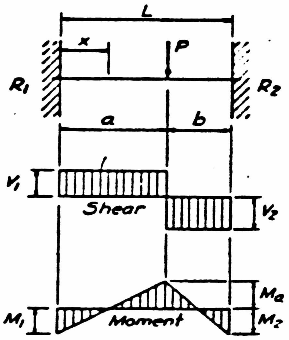
```
BEAM (3.)
R1
        -0.9867
R2
        .0.9867
M1
       -24.6667
M2
        49.3333
MX-X LESS THAN A
       -14.8000
MX-X GREATER THAN A
        59.2000
DX-X LESS THAN A
        -0.0043
DX-X GREATER THAN A
        -0.0012
A GREATER THANB
        25.0000   ?
D-MAX
         0.0043   ?
A LESS THANB
        39.6447
D-MAX
         0.0121
M1/S
         2.2630
M2/S
         4.5260
R1,R2/A-EFF
         0.6578
```

CDI MARINE COMPANY
NAVAL ARCHITECTS AND MARINE ENGINEERS
JACKSONVILLE, FLORIDA

BY Paul C. Horn DATE 1/16/85 SUBJECT Beam 4 SHEET NO. 6 OF 12

CHKD BY ______ DATE ______ Beam fixed at both ends JOB NO. —

Concentrated load at any point



	o.k.	n.g.
BENDING	☐	☐
SHEAR	☐	☐
DEFLECTION	☐	☐

$R_1 = V_1$ (max when $a < b$) .... $= \frac{Pb^2}{L^3}(3a + b)$

$R_2 = V_2$ (max when $a > b$) .... $= \frac{Pa^2}{L^3}(a + 3b)$

M_1 (max when $a < b$) .... $= \frac{Pab^2}{L^2}$

M_2 (max when $a > b$) .... $= \frac{Pa^2b}{L^2}$

M_a (at point of load) .... $= \frac{2Pa^2b^2}{L^3}$

M_x (when $x < a$) .... $= R_1x - \frac{Pab^2}{L^2}$

Δ_{max} $\left(\text{when } a > b \text{ at } x = \frac{2aL}{3a+b}\right)$ ... $= \frac{2Pa^3b^2}{3EI(3a+b)^2}$

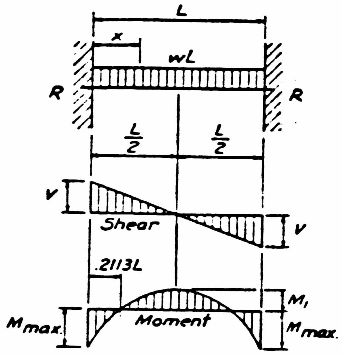
Δa (at point of load) .... $= \frac{Pa^3b^3}{3EIL^3}$

Δx (when $x < a$) .... $= \frac{Pb^2x^2}{6EIL^3}(3aL - 3ax - bx)$

- **P** Concentrated load (kips).
- **a** Measured distance along beam (in.).
- **b** Measured distance along beam which may be greater or less than "a" (in.).
- **l** Total length of beam between reaction points (in.).
- **x** Any distance measured along beam from left reaction (in.).
- **E** Modulus of Elasticity of steel at 29,000 ksi.

```
BEAM (4.)
R1
        0.4871
R2
        1.5129
M1
       19.6301
M2
       41.4413
MA
       26.6409
MX
       36.8692
D-MAX
        0.0136
DA
        0.0122
DX
        0.0034
M1/S
        1.8009
M2/S
        3.8020
R1/A-EFF
        0.3247
R2/A-EFF
        1.0086
```

1	2	3	4	5	6	20	21
P (kips)	a (in.)	b (in.)	L (in.)	x (in.)	I (in.^{4})	S (in.^{3})	A-eff. (in.)
2.0	95	45	140	116	53.8	10.9	1.5



	o.k.	n.g.
BENDING	☐	☐
SHEAR	☐	☐
DEFLECTION	☐	☐

Equivalent Tabular Load* .... $= \frac{2wl}{3}$

$R = V$ .... $= \frac{wl}{2}$

V_x .... $= w\left(\frac{l}{2} - x\right)$

M_{max} (at ends) .... $= \frac{wl^2}{12}$

M_1 (at center) .... $= \frac{wl^2}{24}$

M_x .... $= \frac{w}{12}(6lx - l^2 - 6x^2)$

Δ_{max} (at center) .... $= \frac{wl^4}{384EI}$

Δx .... $= \frac{wx^2}{24EI}(l - x)^2$

w Uniformly distributed load per unit of length (kips per in.).

l Total length of beam between reaction points (in.).

x Any distance measured along beam from left reaction (in.).

E Modulus of Elasticity of steel at 29,000 ksi.

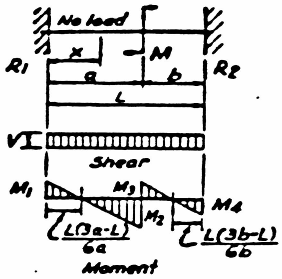
① w (kip/in.)	② a (in.)	③ b (in.)	④ L (in.)	⑤ x (in.)	⑥ I (in.⁴)	⑳ S (in.³)	㉑ A-eff. (in.)
.20			140	116	53.8	10.9	1.5

```
BEAM (5.)
EQ. TAB. LOAD
      18.7600
R=V
      14.0000
VX
      -9.2000
M-MAX
     326.6667
M1
     163.3333
MX
     -48.2667
D-MAX
       0.1282
DX
       0.0414
M-MAX/S
      29.9694
R=V/A-EFF
       9.3333
```

CDI MARINE COMPANY
NAVAL ARCHITECTS AND MARINE ENGINEERS
JACKSONVILLE, FLORIDA

BY Paul C. Hanna DATE 1/16/85 SUBJECT Beam 6 SHEET NO. 8 OF 12

CHKD BY ______ DATE ______ BEAM FIXED BOTH ENDS—NO LOAD—APPLIED MOMENT JOB NO. —



	o.k.	n.g.
BENDING	☐	☐
SHEAR	☐	☐
DEFLECTION	☐	☐

$R_1 = V = -\frac{6Mab}{l^3}$ $R_2 = \frac{6Mab}{l^3}$

$M_1 \ldots\ldots = +\frac{Mb}{l}\left(1 - 3\frac{a}{l}\right)$ $M_2 = -\frac{Mb}{l}\left(1 - 3\frac{a}{l} + 6\frac{a^2}{l^2}\right)$

$M_3 \ldots\ldots = \frac{Ma}{l}\left(1 - 3\frac{b}{l} + 6\frac{b^2}{l^2}\right)$ $M_4 = +\frac{Ma}{l}\left(1 - 3\frac{b}{l}\right)$

M_x (when $x < a$)...... $= -\frac{Mb}{l^3}(l^2 - 3al + 6ax)$

M_x (when $x > a$)...... $= \frac{Ma}{l^3}(l^2 + 3bl - 6bx)$

Δ_x (when $x < a$)...... $= \frac{Mb}{EIl^2}\left(\frac{l^2x^2}{2} - \frac{3alx^2}{2} + ax^3\right)$

Δ_x (when $x > a$)...... $= -\frac{Ma}{EIl^3}\left(\frac{l^2x^2}{2} + \frac{3blx^2}{2} - bx^3 - l^2x + \frac{al^3}{2}\right)$

Δ_a................. $= \frac{Ma^2b}{EIl^3}\left(\frac{l^2}{2} - \frac{3al}{2} + a^2\right) = \frac{Ma^2b^2}{2EIl^3}(l - 2a)$

M moment (kip in.)

a Measured distance along beam (in.).

b Measured distance along beam which may be greater or less than "a" (in.).

l Total length of beam between reaction points (in.).

x Any distance measured along beam from left reaction (in.).

E Modulus of Elasticity of steel at 29,000 ksi.

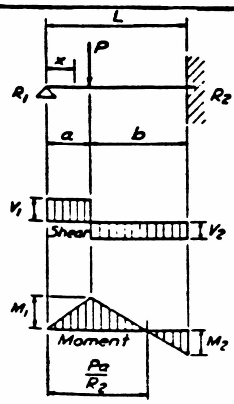
1	2	3	4	5	6	20	21
M (kip in.)	a (in.)	b (in.)	L (in.)	x (in.)	I (in.^{4})	S (in.^{3})	A–eff. (in.)
74	25	50	75	15	41.4	10.9	1.5

```
BEAM (6.)
R1
        -1.3156
R2
         1.3156
M1
         0.0000
M2
       -32.8889
M3
        41.1111
M4
       -24.6667
MX-X LESS THANA
      -19.7333
MX-X GTR.A
       54.2667
DX-X LESS THANA
       -0.0006
DX-X GTR.A
        0.0024
DA
        0.0029
M2/S
        3.0173
M3/S
        3.7717
R1R2/A-EFF
        0.8770
```

CDI MARINE COMPANY
NAVAL ARCHITECTS AND MARINE ENGINEERS
JACKSONVILLE, FLORIDA

BY Paul C. Ham DATE 1/16/85 SUBJECT Beam 7 SHEET NO. 9 OF 12

CHKD BY ______ DATE ______ BEAM FIXED AT ONE END, SUPPORTED AT OTHER— CONCENTRATED LOAD AT ANY POINT JOB NO. —



	o.k.	n.g.
BENDING	☐	☐
SHEAR	☐	☐
DEFLECTION	☐	☐

$R_1 = V_1$ .... $= \frac{Pb^2}{2L^3}(a+2L)$

$R_2 = V_2$ .... $= \frac{Pa}{2L^3}(3L^2 - a^2)$

M_1 (at point of load) .... $= R_1 a$

M_2 (at fixed end) .... $= \frac{Pab}{2L^2}(a+L)$

M_x (when $x < a$) .... $= R_1 x$

M_x (when $x > a$) .... $= R_1 x - P(x-a)$

$\Delta_{max}\left(\text{when } a < .414L \text{ at } x = L\frac{L^2+a^2}{3L^2-a^2}\right)$ .. $= \frac{Pa(L^2-a^2)^3}{3EI(3L^2-a^2)^2}$

$\Delta_{max}\left(\text{when } a > .414L \text{ at } x = L\sqrt{\frac{a}{2L+a}}\right)$. $= \frac{Pab^2}{6EI}\sqrt{\frac{a}{2L+a}}$

Δa (at point of load) .... $= \frac{Pa^2b^3}{12EIL^3}(3L+a)$

Δx (when $x < a$) .... $= \frac{Pb^2x}{12EIL^3}(3aL^2 - 2Lx^2 - ax^2)$

Δx (when $x > a$) .... $= \frac{Pa}{12EIL^3}(L-x)^2(3L^2x - a^2x - 2a^2L)$

- **P** Concentrated load (kips).
- **a** Measured distance along beam (in.).
- **b** Measured distance along beam which may be greater or less than "a" (in.).
- **l** Total length of beam between reaction points (in.).
- **x** Any distance measured along beam from left reaction (in.).
- **E** Modulus of Elasticity of steel at 29,000 ksi.

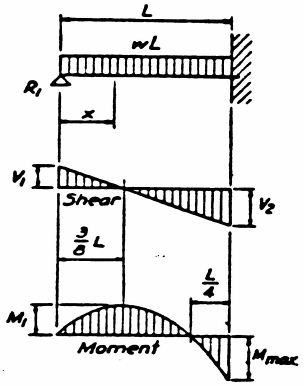
1	2	3	4	5	6	20	21
P (kips)	a (in.)	b (in.)	L (in.)	x (in.)	I (in.⁴)	S (in.³)	A-eff. (in.)
1.2	13	47	60	6.11	13.2	10.9	1.5

```
BEAM (7.)
R1
        0.8161
R2
        0.3839
M1
       10.6093
M2
        7.4338
MX-X LESS THANA
        4.9864
MX-X GTR. THANA
       13.2544
DMAX ALESS.414L
        0.0049
DMAX A GTR.414L
        0.0047
D-A
        0.0041
DX-X LESS THANA
        0.0022
DX-X GTR. THANA
        0.0020
M1/S
        0.9733
M2/S
        0.6820
R1/A
        0.5441
R2/A
        0.2559
```

CDI MARINE COMPANY
NAVAL ARCHITECTS AND MARINE ENGINEERS
JACKSONVILLE, FLORIDA

BY [illegible] DATE 1/16/85 SUBJECT Beam 8 SHEET NO. 10 OF 12

CHKD BY ______ DATE ______ BEAM FIXED AT ONE END, SUPPORTED AT OTHER— UNIFORMLY DISTRIBUTED LOAD JOB NO. —



	o.k.	n.g.
BENDING	☐	☐
SHEAR	☐	☐
DEFLECTION	☐	☐

```
BEAM (8.)
R1=V1
         10.5000
R2=V2-MAX
         17.5000
VX
        -12.7000
M-MAX
        490.0000
M1
        275.6250
MX
       -127.6000
D-MAX
          0.2706
DX
          0.0664
M-MAX/S
         44.9541
R2/A-EFF
         11.6667
```

Equivalent Tabular Load.* .... $= wl$

$R_1 = V_1$ .... $= \frac{3wl}{8}$

$R_2 = V_{2}max$ .... $= \frac{5wl}{8}$

V_x .... $= R_1 - wx$

M_{max} .... $= \frac{wl^2}{8}$

$M_1 \left(\text{at } x = \frac{3}{8}l\right)$ .... $= \frac{9}{128}wl^2$

M_x .... $= R_1x - \frac{wx^2}{2}$

$\Delta max \left[\text{at } x = \frac{L}{16}(1 + \sqrt{33}) = .4215L\right]$.. $= \frac{wl^4}{184.63EI}$

Δx .... $= \frac{wx}{48EI}(l^3 - 3lx^2 + 2x^3)$

w Uniformly distributed load per unit of length (kips per in.).

l Total length of beam between reaction points (in.).

x Any distance measured along beam from left reaction (in.).

E Modulus of Elasticity of steel at 29,000 ksi.

1	2	3	4	5	6	20	21
w (kip/in.)	a (in.)	b (in.)	L (in.)	x (in.)	I (in.^{4})	S (in.^{3})	A-eff. (in.)
.20			140	116	53.8	10.9	1.5

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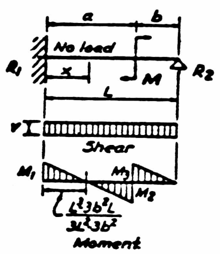
NAVAL ARCHITECTS AND MARINE ENGINEERS
JACKSONVILLE, FLORIDA

BY [signature] DATE 1/16/85 SUBJECT Beam 9 SHEET NO. 11 OF 12

CHKD BY ______ DATE ______ BEAM FIXED ONE END—NO LOAD—APPLIED MOMENT JOB NO. —



	o.k.	n.g.
BENDING	☐	☐
SHEAR	☐	☐
DEFLECTION	☐	☐

$R_1 = V \ldots\ldots = -\frac{3M}{2L}\left(1-\frac{b^2}{L^2}\right)$ $\qquad R_2 \ldots\ldots = \frac{3M}{2L}\left(1-\frac{b^2}{L^2}\right)$

$M_1 \ldots\ldots\ldots = \frac{M}{2}\left(1-3\frac{b^2}{L^2}\right)$ $\qquad M_2 \ldots\ldots = \frac{3Mb}{2L}\left(1-\frac{b^2}{L^2}\right) - M$

$M_3 \ldots\ldots\ldots = \frac{3Mb}{2L}\left(1-\frac{b^2}{L^2}\right)$

$M_x \text{ (when } x < a) \ldots = \frac{3M}{2L}\left(1-\frac{b^2}{L^2}\right)(L-x) - M$

$M_x \text{ (when } x > a) \ldots = \frac{3M}{2L}\left(1-\frac{b^2}{L^2}\right)(L-x)$

$\Delta_x \text{ (when } x < a) \ldots = \frac{Mx^2}{2EI}\left[\frac{3}{L}\left(1-\frac{b^2}{L^2}\right)\left(\frac{x}{6}-\frac{L}{2}\right)+1\right]$

$\Delta_x \text{ (when } x > a) \ldots = \frac{3M}{2EIL}\left(1-\frac{b^2}{L^2}\right)\left(\frac{L^3}{3}-\frac{Lx^2}{2}+\frac{x^3}{6}\right) - \frac{Ma}{EI}(L-x)$

$\Delta_a \ldots\ldots\ldots\ldots\ldots = \frac{Ma^2}{2EI}\left[\frac{a(2L-a)(a-3L)}{2L^3}+1\right]$

- **M** moment (kip in.)
- **a** Measured distance along beam (in.).
- **b** Measured distance along beam which may be greater or less than "a" (in.).
- **l** Total length of beam between reaction points (in.).
- **x** Any distance measured along beam from left reaction (in.).
- **E** Modulus of Elasticity of steel at 29,000 ksi.

1	2	3	4	5	6	20	21
M (kip in.)	a (in.)	b (in.)	L (in.)	x (in.)	I ($in.^4$)	S ($in.^3$)	A–eff. (in.)
74	25	50	75	15	41.4	10.9	1.5

```
BEAM (9.) .
R1
      -0.8222
R2
       0.8222
M1
     -12.3333
M2
     -32.8889
M3
      41.1111
MX-X LESS THANA
     -24.6667
MX-X GTR. THANA
      49.3333
DX-X LESS THANA
       0.0015
DX-X GTR. THANA
      -0.0015
D-A
       0.0050
M1/S
      -1.1315
M2/S
      -3.0173
M3/S
       3.7717
R1R2/A-EFF
       0.5481
```

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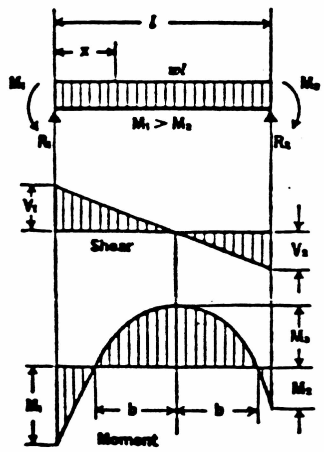
NAVAL ARCHITECTS AND MARINE ENGINEERS
JACKSONVILLE, FLORIDA

BY [signature] DATE 1/16/85 SUBJECT Beam 10 SHEET NO. 12 OF 12

CHKD BY ______ UNIFORMLY DISTRIBUTED LOAD AND VARIABLE END MOMENTS JOB NO. —

	o.k.	n.g.
BENDING	☐	☐
SHEAR	☐	☐
DEFLECTION	☐	☐




```
BEAM (10.)
R1
         3.7167
R2
         8.2833
VX
         2.4947
M3 X=
        18.5833
M3
        18.5340
MX
         2.9756
B INFL. PTS.
        13.6140
DX
        -0.0004
M3/S
         1.7004
R1/A-EFF
         2.4778
R2/A-EFF
         5.5222
```

$$R_1 = V_1 = \frac{wl}{2} + \frac{M_1 - M_2}{l}$$

$$R_2 = V_2 = \frac{wl}{2} - \frac{M_1 - M_2}{l}$$

$$V_x = w\left(\frac{l}{2} - x\right) + \frac{M_1 - M_2}{l}$$

$$M_3 \left(\text{at } x = \frac{l}{2} + \frac{M_1 - M_2}{wl}\right) = \frac{wl^2}{8} - \frac{M_1 + M_2}{2} + \frac{(M_1 - M_2)^2}{2wl^2}$$

$$M_x = \frac{wx}{2}(l - x) + \left(\frac{M_1 - M_2}{l}\right)x - M_1$$

$$b\left(\begin{matrix}\text{To locate} \\ \text{inflection points}\end{matrix}\right) = \sqrt{\frac{l^2}{4} - \left(\frac{M_1 + M_2}{w}\right) + \left(\frac{M_1 - M_2}{wl}\right)^2}$$

$$\Delta_x = \frac{wx}{24EI}\left[x^3 - \left(2l + \frac{4M_1}{wl} - \frac{4M_2}{wl}\right)x^2 + \frac{12M_1}{w}x + l^3 - \frac{8M_1 l}{w} - \frac{4M_2 l}{w}\right]$$

w Uniformly distributed load

l Total length of beam between reaction points (in.).

x Any distance measured along beam from left reaction (in.).

E Modulus of Elasticity of steel at 29,000 ksi.

1	2	3	4	5	6	20	21	7	8
w (kip/in.)	~~a (in.)~~	~~b (in.)~~	L (in.)	x (in.)	I (in.^{4})	S (in.^{3})	A-eff. (in.)	M_1 (kip in.)	M_2 (kip in.)
.2			60	6.11	13.2	10.9	1.5	16	153

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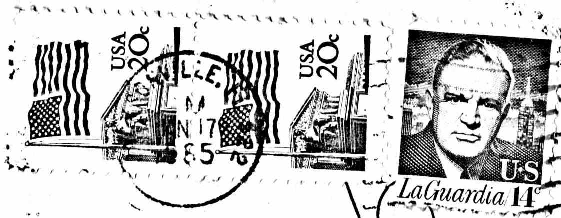

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